

BIOLOGICAL INTEGRITY OF DOG CREEK AND EAGLE CREEK BASED ON THE STRUCTURE AND COMPOSITION OF THE BENTHIC ALGAE COMMUNITY

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Summary

In August 2003, periphyton samples were collected from Dog Creek and Eagle Creek in the Bullwhacker-Dog TMDL planning area in north central Montana for the purpose of assessing whether these streams are water-quality limited and in need of TMDLs. The samples were collected following MDEQ standard operating procedures, processed and analyzed using standard methods for periphyton, and evaluated following modified USEPA rapid bioassessment protocols for wadeable streams.

A very large number of motile and highly motile diatoms at the Dog Creek site indicated **severe impairment from sedimentation** and non-support of aquatic life uses for a prairie stream. Depressed diatom species diversity and a large number of pollution tolerant diatoms also indicated elevated levels of organic matter and inorganic nutrients at this site, which resulted in moderate impairment.

The two upstream sites on Eagle Creek had excellent biological integrity for a prairie stream, indicating no impairment and full support of aquatic life uses. Even when compared with biocriteria for a mountain stream, diatom metrics at the upper site indicated only minor impairment from organic loading and sedimentation and full support of aquatic life uses. The two sites had similar algal floras, indicating that little or no change in environmental conditions occurred between them.

A major change in taxonomic composition and community structure took place between Eagle Creek site 2 and Eagle Creek site 3, which shared only 14% of their diatom floras. The latter site supported only one genus of non-diatom algae (*Chara*) and a significantly smaller number of diatom species. The diatom species that were present at this site indicated **moderate impairment from sedimentation** and minor impairment from organic loading.

Diatom species indicated alkaline waters and eutrophic conditions at all four sites. Diatom species indicated variable conditions among the four sites with respect to salinity, nitrogen uptake, oxygen demand, saprobity, dewatering, and sedimentation.

Introduction

This report evaluates the biological integrity¹, support of aquatic life uses, and probable causes of stress or impairment to aquatic communities in Dog Creek and Eagle Creek in the Bullwhacker-Dog TMDL planning area of north central Montana. The purpose of this report is to provide information that will help the State of Montana determine whether these streams are water-quality limited and in need of TMDLs.

The federal Clean Water Act directs states to develop water pollution control plans (Total Maximum Daily Loads or TMDLs) that set limits on pollution loading to water-quality limited waters. Water-quality limited waters are lakes and stream segments that do not meet water-quality standards, that is, that do not fully support their beneficial uses. The Clean Water Act and USEPA regulations require each state to (1) identify waters that are water-quality limited, (2) prioritize and target waters for TMDLs, and (3) develop TMDL plans to attain and maintain water-quality standards for all water-quality limited waters.

Evaluation of aquatic life use support in this report is based on the species composition and structure of periphyton (benthic algae, phytobenthos) communities at stream sites that were sampled in August 2002. Periphyton is a diverse assortment of simple photosynthetic organisms called algae that live attached to or in close proximity of the stream bottom. Some algae form long filaments or large colonies and are conspicuous to the unaided eye. But most, including the ubiquitous diatoms, can be seen and identified only with the aid of a microscope. The periphyton community is a basic biological component of all aquatic ecosystems. Periphyton accounts for much of the primary production and biological diversity in Montana streams (Bahls et al. 1992). Plafkin et al. (1989) and Barbour et al. (1999) list several advantages of using periphyton in biological assessments.

¹ *Biological integrity* is defined as “the ability of an aquatic ecosystem to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of natural habitats within a region” (Karr and Dudley 1981).

Project Area and Sampling Sites

The project area is located in north central Montana in Chouteau and Fergus Counties. Both Dog Creek and Eagle Creek are tributaries of the Missouri River. Eagle Creek heads in the Bearpaw Mountains and flows southwesterly, entering the Missouri River downstream from Virgelle. Eagle Creek transects three ecoregions: the Northern Rockies, Montana Valley and Foothill Prairies, and the Northwestern Glaciated Plains (Woods et al. 1999). The upper sampling site is in the foothill ecoregion and the lower sites are in the plains ecoregion.

Dog Creek heads in the Moccasin Mountains north of Lewistown and flows northwesterly, entering the Missouri River just below the mouth of the Judith River. Dog Creek also transects the Northern Rockies and Montana Valley and Foothill Prairies Ecoregions, but for most of its course it flows through the Northwestern Great Plains Ecoregion. The sampling site on Dog Creek is located in the Northwestern Great Plains Ecoregion.

Periphyton samples were collected at 3 sites on Eagle Creek and 1 site on Dog Creek (Table 1, Maps 1-4). Elevations at the sampling sites range from about 4000 feet above mean sea level at the upper site on Eagle Creek to about 2600 feet at the lower site on Eagle Creek. The middle site on Eagle Creek and the site on Dog Creek are both at about 3000 feet elevation. Vegetation in the study area is mainly mixed conifer forest in the upper reaches of both streams and mixed grassland along the middle and lower reaches (USDA 1976). Land use is primarily livestock grazing with some mining in the headwaters.

Methods

Periphyton samples were collected following standard operating procedures of the MDEQ Planning, Prevention, and Assistance Division. Using appropriate tools, microalgae were scraped, brushed, or sucked from natural substrates in proportion to the importance of those substrates at each study site. Macroalgae were picked by hand in proportion to their abundance at the site. All collections of microalgae and macroalgae were pooled into a common container

and preserved with Lugol's (IKI) solution. Aquatic Plant Field Sheets (Appendix A) were completed at the time of periphyton collection.

The samples were examined to estimate the relative abundance and rank by biovolume of diatoms and genera of soft (non-diatom) algae according to the method described in Bahls (1993). Soft algae were identified using Smith (1950), Prescott (1962, 1978), John et al. (2002), and Wehr and Sheath (2003). These books also served as references on the ecology of the soft algae, along with Palmer (1969, 1977).

After the identification of soft algae, the raw periphyton samples were cleaned of organic matter using sulfuric acid, potassium dichromate, and 3% hydrogen peroxide. Then, permanent diatom slides were prepared using Naphrax, a high refractive index mounting medium, following *Standard Methods for the Examination of Water and Wastewater* (APHA 1998). Approximately 400 diatom cells (800 valves) were counted at random and identified to species. The following were the main taxonomic references for the diatoms: Krammer and Lange-Bertalot 1986, 1988, 1991a, 1991b; Lange-Bertalot 2001; Krammer 2002. Diatom naming conventions followed those adopted by the Academy of Natural Sciences for USGS NAWQA samples (Morales and Potapova 2000). Van Dam et al. (1994) was the main ecological reference for the diatoms.

The diatom proportional counts were used to generate an array of diatom association metrics. A metric is a characteristic of the biota that changes in some predictable way with increased human influence (Barbour et al. 1999). Diatoms are particularly useful in generating metrics because there is a wealth of information available in the literature regarding the pollution tolerances and water quality preferences of common diatom species (e.g., Lowe 1974, Beaver 1981, Lange-Bertalot 1996, Van Dam et al. 1994).

Values for selected metrics were compared to biocriteria (numeric thresholds) developed for streams in the Great Plains ecoregions of Montana (Table 2). These criteria are based on the distribution of metric values measured in least-impaired reference streams (Bahls et al. 1992) and metric values measured in streams that are known to be impaired by various sources and causes

of pollution (Bahls 1993). The biocriteria in Table 2 are valid only for samples collected during the summer field season (June 21-September 21).

The criteria in Table 2 distinguish among four levels of stress or impairment and three levels of aquatic life use support: (1) no impairment or only minor impairment (full support); (2) moderate impairment (partial support); and (3) severe impairment (nonsupport). These impairment levels correspond to excellent, good, fair, and poor biological integrity, respectively.

Quality Assurance

Several steps were taken to assure that the study results are accurate and reproducible.

Upon receipt of the samples, station and sample attribute data were recorded in the Montana Diatom Database and the samples were assigned a unique number, e.g., 2588-01. The first part of this number (2588) designates the sampling site (Dog Creek at Econom) and the second part (01) designates the number of periphyton samples that have been collected at this site for which data have been entered into the Montana Diatom Database.

Sample observations and analyses of soft (non-diatom) algae were recorded in a lab notebook along with information on the sample label. A portion of the raw sample was used to make duplicate diatom slides. The slide used for the diatom proportional count will be deposited in the Montana Diatom Collection at the University of Montana Herbarium in Missoula. The duplicate slide will be retained by *Hannaea* in Helena. Diatom proportional counts have been entered into the Montana Diatom Database.

Results and Discussion

Results are presented in Tables 3, 4 and 5, which are located near the end of this report following the references section. Completed Aquatic Plant Field Sheets are included as Appendix A. Appendix B consists of a series of diatom reports, one for each sample. Each

diatom report contains an alphabetical list of diatom species and their percent abundances, and values for 65 different diatom metrics and ecological attributes.

Field Notes (R. Ridenour)

Dog Creek. In decreasing order of importance, rock, sediment, and higher plants were the most common substrates at this site. Macroalgae covered about 10% of the substrate area and the remaining 90% appeared to be bare of algal growth.

Eagle Creek. In decreasing order of importance, rock, wood, sediment, and filamentous algae and macrophytes were substrates for algal growth at the upper site. Macrophytes covered 20% of the substrate area, macroalgae 10%, and mosses 1%. All plants appeared to be healthy and growing to mature. At the middle site, rock, sediment, and macrophytes/filamentous algae were the most important algal substrates, followed by wood. Forty percent of the substrate area was covered by microalgae and 40% was covered by macrophytes. Plants were growing to mature. Rock, sediment, and filamentous macroalgae were the most important substrates at the lower site. Here macroalgae and macrophytes each covered about 20% of available substrates and appeared to be mature or senescent. Moss was also present, covering about 1% of the area.

Sample Notes

Dog Creek. The sample from Dog Creek was silty and contained plant stems and leaves.

Eagle Creek. The sample from the upper site on Eagle Creek was packed full of filamentous algae. The sample collected from below Highway 236 was silty and contained macrophytes. The sample from the lower site on Eagle Creek had about three-quarters of an inch of sediment on the bottom of the container. *Chara* was the only visible alga in this sample.

Non-Diatom Algae

Dog Creek. Seven genera of cyanobacteria dominated the sample from Dog Creek and were the only non-diatom algae present (Table 3). Diatoms were common and ranked 4th in biovolume. Green algae, including filamentous macroalgae, were conspicuously absent from this sample.

Eagle Creek. The upper site on Eagle Creek supported a diverse assortment of 13 genera of yellow-green algae, green algae, cyanobacteria, and euglenoid algae (Table 3). The sample was dominated by two genera of yellow-green algae (*Tribonema* and *Vaucheria*) that indicate cool water temperatures and constant flows. Filamentous green algae were also abundant here. As a group, diatoms were frequent and ranked fifth in biovolume among the genera.

Six genera of non-diatom algae were found in the sample from the middle site on Eagle Creek and all but one of these were green algae (Table 3). *Tribonema* was present here but it was much less abundant than it was upstream. Diatoms were abundant and ranked 1st in biovolume.

Chara, a plant-like green alga with erect stems, dominated the sample from the lower site on Eagle Creek and was the only non-diatom alga present (Table 3). *Chara* prefers alkaline waters and is found mostly in ponds and stream backwaters with muddy bottoms and little or no current. Diatoms were common here and ranked a distant 2nd in biovolume.

Diatoms

Four of the major diatom species in Dog Creek and Eagle Creek are sensitive to organic pollution and all four were abundant only at the upper and middle sites on Eagle Creek (Table 4). Six of the major species are somewhat tolerant of organic pollution and these were present at all sites. The 3 major diatom species that are most tolerant of organic pollution were present only in Dog Creek and at the lower site on Eagle Creek (Table 4). *Navicula vilaplantii*, a new species just described in 2000, is usually found in eutrophic waters with average to higher conductivity

(Lange-Bertalot 2001). It was abundant only at the lower site on Eagle Creek. The tolerance of this species to organic pollution is unknown.

Dog Creek. The major diatom species in Dog Creek were either somewhat tolerant of organic pollution or very tolerant of organic pollution (Table 4). The dominant species here was *Nitzschia inconspicua*. This is a facultative nitrogen heterotroph and a species that prefers eutrophic waters with moderate BOD loads and oxygen content (Van Dam et al. 1994). Diatom metrics for Dog Creek indicated **severe impairment from sedimentation**. Depressed diatom species diversity indicated moderate impairment and partial support of aquatic life uses. This stress was probably due to excess nutrients, primarily nitrogen, which resulted in an unusually large population of *Nitzschia inconspicua*.

Eagle Creek. The upper site on Eagle Creek had excellent biological integrity for a prairie stream (Table 4). Even when compared to criteria for a mountain stream (Bahls 1993), diatom metrics at this site indicated only minor impairment from organic loading and sedimentation. Diatom species richness and diversity were excellent. The major diatom species here were mostly sensitive to or only somewhat tolerant of organic pollution. The most abundant species at sites 1 and 2 was *Staurosira construens*, a non-motile araphid species that indicates stable flows and little physical disturbance.

Diatom metrics at the middle site on Eagle Creek indicated good biological integrity for a prairie stream (Table 4). Only a few abnormal cells of *Diatoma vulgare* kept this site from having excellent biological integrity. Abnormal cells of this species are a common occurrence, even in unpolluted waters (personal observation). Diatom species richness and diversity were excellent here. This site shared about half of its diatom flora with the upper site on Eagle Creek, but only about 13% with the downstream site near the mouth. This indicates a major change in the diatom flora and in ecological conditions between this site and the lower site on Eagle Creek.

Moderate impairment from sedimentation and partial support of aquatic life uses was indicated at Eagle Creek site 3 (Table 4). A somewhat depressed pollution index also indicated minor loading of organic pollutants at this site. Diatom species richness and diversity were less

than they were at the two upstream sites. The dominant species here was *Navicula symmetrica*, which indicates brackish, eutrophic waters with moderate organic loading (Lange-Bertalot 2001).

Several ecological attributes were selected from the diatom reports in the appendix and modal categories of these attributes were extracted to characterize water quality tendencies at these four sites (Table 5). The majority of diatoms at all of the sites indicated alkaline and eutrophic waters, but the sites differed with respect to other ecological attributes.

Most of the diatoms in Dog Creek were highly motile, which corresponds to the severe impairment from sedimentation that was noted at this site (Table 5). Motile diatoms are able to maintain their position on aggrading substrates in depositional habitats. Similarly, the modal category for motility at Eagle Creek site 3 was moderately motile, which corresponds to the moderately impaired status for this site. The upper two sites on Eagle Creek supported mostly non-motile diatoms, which are not adapted to living on aggrading substrates.

The modal category for salinity was fresh-brackish at the upper two sites on Eagle Creek (Table 5). Brackish-fresh, the modal category at the downstream site on Eagle Creek, indicated a significant increase in salinity at this site. The modal category in Dog Creek was also brackish-fresh.

Most diatoms in Dog Creek have moderate requirements for dissolved oxygen and indicate elevated loads of organic matter (alpha-mesosaprobous). At Eagle Creek site 1, most diatoms also indicate moderate demand for dissolved oxygen, but the loading of organic matter here is smaller (beta-mesosaprobous). The modal category for dissolved oxygen at Eagle Creek site 2 was “continuously high”, which indicates well-aerated water with only somewhat elevated organic loads (beta-mesosaprobous). The modal category for oxygen demand and saprobity at Eagle Creek site 3 was “not classified”.

Most diatoms in Dog Creek were facultative nitrogen heterotrophs, meaning that they are capable of using organic nitrogen (urea and amino acids) as a source of nutrition (Table 5). In contrast, most diatoms at the upper two sites on Eagle Creek were nitrogen autotrophs, meaning

that they require inorganic nitrogen (nitrates and ammonia) as nutrients. These diatoms also tolerate elevated levels of organic nitrogen in the water. The modal category for nitrogen uptake at Eagle Creek site 3 was “not classified”.

Differences in moisture categories were noted between the 4 sites, which indicates the degree to which the sites are dewatered (Table 5). The most persistent flows (and least dewatering) were recorded at Eagle Creek site 2, where the modal category is of diatoms that are rarely found outside water bodies. The site with the next most persistent flows was Eagle Creek site 1, where most diatoms are typically found in water bodies and only sometimes on wet or moist substrates. The largest fluctuations in streamflow were noted in Dog Creek and at Eagle Creek site 3, where most diatoms are found mainly in waterbodies but also regularly on wet or moist substrates.

References

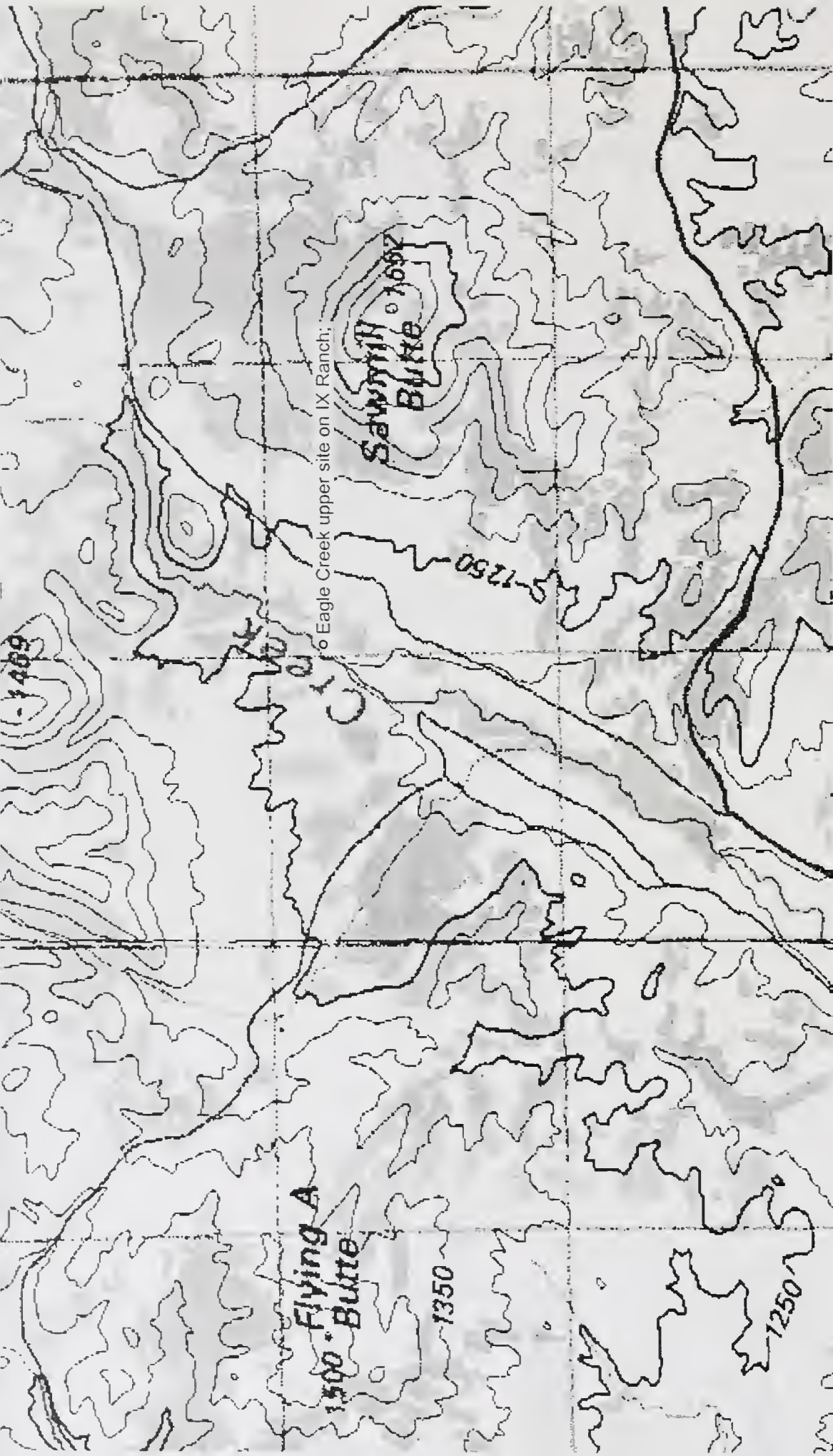
- APHA. 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edition. American Public Health Association, Washington, D.C.
- Bahls, L.L. 1979. Benthic diatom diversity as a measure of water quality. *Proceedings of the Montana Academy of Sciences* 38:1-6.
- Bahls, L.L. 1993. *Periphyton Bioassessment Methods for Montana Streams* (revised). Montana Department of Health and Environmental Sciences, Helena.
- Bahls, L.L., Bob Bukantis, and Steve Tralles. 1992. *Benchmark Biology of Montana Reference Streams*. Montana Department of Health and Environmental Sciences, Helena.
- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. *Rapid Bioassessment Protocols for Use in Streams and Wadeable Rivers: Periphyton, Benthic Macroinvertebrates and Fish*. Second Edition. EPA/841-B-99-002. U.S. Environmental Protection Agency, Office of Water, Washington, D.C.
- Beaver, Janet. 1981. *Apparent Ecological Characteristics of Some Common Freshwater Diatoms*. Ontario Ministry of The Environment, Technical Support Section, Don Mills, Ontario.
- Johansen, J.R. 1999. Diatoms of Aerial Habitats. Chapter 12 *in* Stoermer, E.F., and J.P. Smol (eds.), *The Diatoms: Applications For the Environmental and Earth Sciences*, Cambridge University Press, New York.
- John, D.M., B.A. Whitton, and A.J. Brook (eds.). 2002. *The Freshwater Algal Flora of the British Isles: An Identification Guide to Freshwater and Terrestrial Algae*. Cambridge University
- Karr, J.R., and D.R. Dudley. 1981. Ecological perspectives on water quality goals. *Environmental Management* 5:55-69.

- Krammer, Kurt. 2002. *Cymbella*. Volume 3 in *Diatoms of Europe*, Horst Lange-Bertalot, ed. A.R.G. Gantner Verlag K.G., Germany.
- Krammer, K., and H. Lange-Bertalot. 1986. Bacillariophyceae, Part 2, Volume 1: Naviculaceae. In Ettl, H., J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), *Freshwater Flora of Middle Europe*. Gustav Fischer Publisher, New York.
- Krammer, K., and H. Lange-Bertalot. 1988. Bacillariophyceae, Part 2, Volume 2: Bacillariaceae, Epithemiaceae, Surirellaceae. In Ettl, H., J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), *Freshwater Flora of Middle Europe*. Gustav Fischer Publisher, New York.
- Krammer, K., and H. Lange-Bertalot. 1991a. Bacillariophyceae, Part 2, Volume 3: Centrales, Fragilariaceae, Eunotiaceae. In Ettl, H., J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), *Freshwater Flora of Middle Europe*. Gustav Fischer Publisher, Stuttgart.
- Krammer, K., and H. Lange-Bertalot. 1991b. Bacillariophyceae, Part 2, Volume 4: Achnanthaceae, Critical Supplement to *Navicula* (Lineolatae) and *Gomphonema*, Complete List of Literature for Volumes 1-4. In Ettl, H., G. Gartner, J. Gerloff, H. Heynig, and D. Mollenhauer (eds.), *Freshwater Flora of Middle Europe*. Gustav Fischer Publisher, Stuttgart.
- Lange-Bertalot, Horst. 1979. Pollution tolerance of diatoms as a criterion for water quality estimation. *Nova Hedwigia* 64:285-304.
- Lange-Bertalot, Horst. 1996. Rote Liste der limnischen Kieselalgen (Bacillariophyceae) Deutschlands. *Schr.-R. f. Vegetationskde.*, H. 28, pp. 633-677. BfN, Bonn-Bad Godesberg.
- Lange-Bertalot, Horst. 2001. *Navicula sensu stricto*: 10 Genera Separated from *Navicula sensu lato*; *Frustulia*. Volume 2 in *Diatoms of Europe*, Horst Lange-Bertalot, ed. A.R.G. Gantner Verlag K.G., Germany.
- Lowe, R.L. 1974. Environmental Requirements and Pollution Tolerance of Freshwater Diatoms. EPA-670/4-74-005. U.S. Environmental Protection Agency, National Environmental Research Center, Office of Research and Development, Cincinnati, Ohio.
- McFarland, B.H., B.H. Hill, and W.T. Willingham. 1997. Abnormal *Fragilaria* spp. (Bacillariophyceae) In streams impacted by mine drainage. *Journal of Freshwater Ecology* 12(1):141-149.
- Morales, E.A., and Marina Potapova. 2000. Third NAWQA Workshop on Harmonization of Algal Taxonomy, May 2000. Patrick Center for Environmental Research, The Academy of Natural Sciences, Philadelphia.
- Palmer, C.M. 1969. A composite rating of algae tolerating organic pollution. *Journal of Phycology* 5:78-82.
- Palmer, C.M. 1977. *Algae and Water Pollution: An Illustrated Manual on the Identification, Significance, and Control of Algae in Water Supplies and in Polluted Water*. EPA-600/9-77-036.
- Plafkin, J.L., M.T. Barbour, K.D. Porter, S.K. Gross, and R.M. Hughes. 1989. Rapid Bioassessment Protocols for Use in Rivers and Streams: Benthic Macroinvertebrates and Fish. EPA 440-4-89-001.
- Prescott, G.W. 1962. *Algae of the Western Great Lakes Area*. Wm. C. Brown Company, Dubuque, Iowa.
- Prescott, G.W. 1978. *How to Know the Freshwater Algae*. Third Edition. Wm. C. Brown Company Publishers, Dubuque, Iowa.
- Renfro, H.B., and D.E. Feray. 1972. *Geological Highway Map of the Northern Rocky Mountain Region*. American Association of Petroleum Geologists, Tulsa, Oklahoma.
- Smith, G.M. 1950. *The Fresh-Water Algae of The United States*. McGraw-Hill Book Company, New York.

- Stevenson, R.J., and Y. Pan. 1999. Assessing Environmental Conditions in Rivers and Streams with Diatoms. Chapter 2 *in* Stoermer, E.F., and J.P. Smol (eds.), *The Diatoms: Applications For the Environmental and Earth Sciences*, Cambridge University Press, New York.
- Stewart, W.D.P., P. Rowell, and A.N. Rai. 1980. Symbiotic Nitrogen-Fixing Cyanobacteria. Pp. 239-277 in Stewart, W.D.P., and J. Gallo (eds.), *Nitrogen Fixation*, Academic Press, New York.
- USDA. 1976. Climax Vegetation of Montana (map). U.S. Department of Agriculture, Soil Conservation Service, Cartographic Unit, Portland.
- USEPA. 2000. Level III Ecoregions of the Continental United States (map). U.S. Environmental Protection Agency, Corvallis, Oregon.
- Van Dam, Herman, Adrienne Mertens, and Jos Sinkeldam. 1994. A coded checklist and ecological Indicator values of freshwater diatoms from The Netherlands. *Netherlands Journal of Aquatic Ecology* 28(1):117-133.
- Weber, C.I. (ed.). 1973. *Biological Field and Laboratory Methods for Measuring the Quality of Surface Waters and Effluents*. EPA-670/4-73-001. U.S. Environmental Protection Agency, National Environmental Research Center, Office of Research and Development, Cincinnati, Ohio.
- Wehr, J.D., and R.G. Sheath. 2003. *Freshwater Algae of North America: Ecology and Classification*. Academic Press, New York.
- Whittaker, R.H. 1952. A study of summer foliage insect communities in the Great Smoky Mountains. *Ecological Monographs* 22:1-44.
- Woods, A.J., Omernik, J.M., Nesser, J.A., Shelden, J., and S.H. Azevedo. 1999. Ecoregions of Montana (color poster with map), U.S. Geological Survey, Reston, Virginia.



Map 1. Dog Creek at Econom (site 01).



Map 2. Eagle Creek upper site on IX Ranch (site 01).

BIG SANDY 23 MI.

BIG SANDY 18 MI.

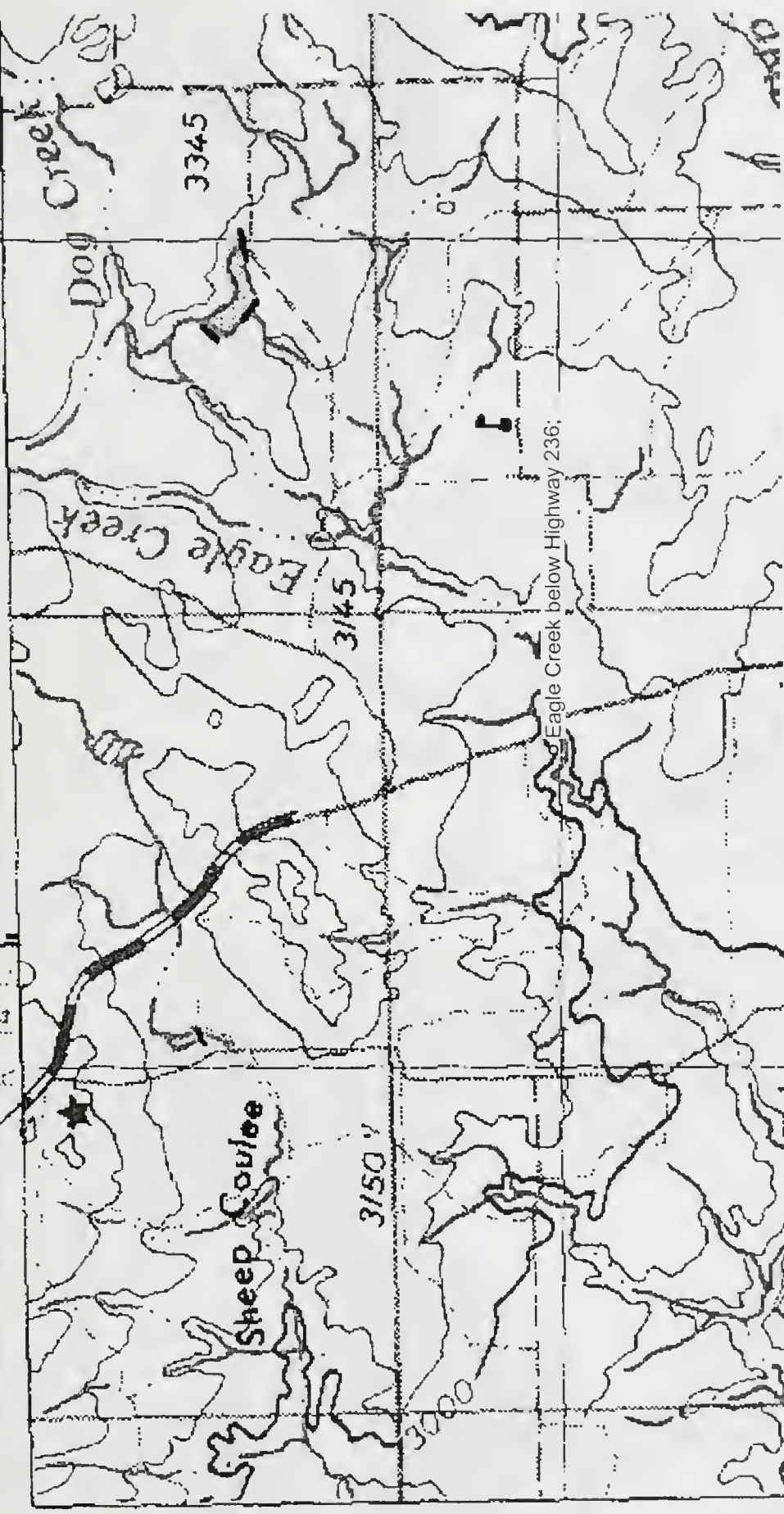
59

1 900 000 FEET (NORTH)

58

110°00'

48°00'



Map 3. Eagle Creek middle site below Highway 236 (site 02).



Map 4. Eagle Creek near mouth (site 03).

Table 1. Location of periphyton sampling stations in the Bullwhacker-Dog TMDL planning area, 2002.

Station	MDEQ Station Code	Hannaea Sample Number	Latitude	Longitude	Sample Date
Dog Creek at Econom	M23DOGCR01	2588-01	47 38 21	109 22 43	8/21/02
Eagle Creek upper site on IX Ranch	M23EAGLC01	2589-01	48 06 03	109 46 08	8/22/02
Eagle Creek below Highway 236	M23EAGLC02	2590-01	47 56 27	109 52 41	8/22/02
Eagle Creek near mouth	M23EAGLC03	2591-01	47 55 02	110 03 11	8/22/02

Table 2. Diatom association metrics used by the State of Montana to evaluate biological integrity in prairie streams: references, range of values, expected response to increasing impairment or natural stress, and criteria for rating levels of biological integrity. The lowest rating for any one metric is the rating for that site.

Biological Integrity/ Impairment or Stress/ Use Support	No. of Species Counted ¹	Diversity Index ² (Shannon)	Pollution Index ³	Siltation Index ⁴	Disturbance Index ⁵	% Dominant Species ⁶	Similarity Index ⁷
Excellent/None Full Support	>39	>3.99	>2.25	<50.0	<25.0	<25.0	>59.9
Good/Minor Full Support	30-39	3.00-3.99	1.76-2.25	50.0-69.9	25.0-49.9	25.0-49.9	40.0-59.9
Fair/Moderate Partial Support	20-29	2.00-2.99	1.25-1.75	70.0-89.9	50.0-74.9	50.0-74.9	20.0-39.9
Poor/Severe Nonsupport	<20	<2.00	<1.25	>89.9	>74.9	>74.9	<20.0
References	Bahls 1979 Bahls 1993	Bahls 1979	Bahls 1993	Bahls 1993	Barbour et al. 1999	Barbour et al. 1999	Whittaker 1952
Range of Values	0-100+	0.00-5.00+	1.00-3.00	0.0-90.0+	0.0-100.0	~5.0-100.0	0.0-100.0
Expected Response	Decrease	Decrease	Decrease	Increase	Increase	Increase	Decrease

¹Based on a proportional count of 400 cells (800 valves)

²Base 2 [bits] (Weber 1973)

³Composite numeric expression of the pollution tolerances assigned by Lange-Bertalot (1979) to the common diatom species

⁴Sum of the percent abundances of all species in the genera *Navicula*, *Nitzschia*, and *Surirella*

⁵Percent abundance of *Achnanthes minutissimum* (synonym: *Achnanthes minutissima*)

⁶Percent abundance of the species with the largest number of cells in the proportional count

⁷Percent Community Similarity (Whittaker 1952)

Table 3. Relative abundance of cells and ordinal rank by biovolume of diatoms (Division Bacillariophyta) and genera of non-diatom algae in periphyton samples collected from Dog Creek and Eagle Creek in 2002: d = dominant; a = abundant; f = frequent; c = common; o = occasional; r = rare.

Taxa	Dog Creek	Eagle 01	Eagle 02	Eagle 03
Cyanophyta				
<i>Amphithrix</i>	o/8			
<i>Anabaena</i>	o/6	o/10		
<i>Calothrix</i>	f/1			
<i>Hydrocoleum</i>	f/2			
<i>Oscillatoria</i>	o/5			
<i>Phormidium</i>	c/3			
<i>Schizothrix</i>	o/7			
Chlorophyta				
<i>Ankistrodesmus</i>		o/12		
<i>Chara</i>				d/1
<i>Cladophora</i>			a/2	
<i>Closterium</i>		c/7	r/7	
<i>Cosmarium</i>		o/9		
<i>Microspora</i>		f/4		
<i>Mougeotia</i>		c/6	o/6	
<i>Oedogonium</i>		o/8	o/5	
<i>Scenedesmus</i>		o/11		
<i>Spirogyra</i>		a/3	f/3	
<i>Staurastrum</i>		r/14		
Euglenophyta				
<i>Euglena</i>		r/13		
Xanthophyta				
<i>Tribonema</i>		d/1	c/4	
<i>Vaucheria</i>		a/2		
Bacillariophyta				
	c/4	f/5	a/1	c/2
# Non-Diatom Genera	7	13	6	1

Table 4. Percent abundance of major diatom species¹ and values of selected diatom association metrics for periphyton samples collected from Dog Creek and Eagle Creek in 2002. Underlined values indicate minor stress; **bold values** indicate moderate stress; underlined and bold values indicate severe stress; all other values indicate no stress and full support of aquatic life uses when compared to criteria for prairie streams in Table 2.

Species/Metric	PTC ²	Dog Creek	Eagle 01	Eagle 02	Eagle 03
<i>Cocconeis placentula</i>	3		6.42	2.91	
<i>Fragilaria vaucheriae</i>	2		12.71	4.61	
<i>Navicula capitatoradiata</i>	2		0.61	7.15	
<i>Navicula symmetrica</i>	2				22.41
<i>Navicula vandamii</i>	1				6.28
<i>Navicula vilaplantii</i>	?			0.24	9.61
<i>Nitzschia inconspicua</i>	2	46.52		1.58	6.53
<i>Nitzschia liebetruhi</i>	2	15.67			1.48
<i>Nitzschia palea</i>	1	5.35	1.45	1.94	1.23
<i>Nitzschia perspicua</i>	1	7.59			
<i>Nitzschia reversa</i>	2	1.12		0.12	12.81
<i>Pseudostaurosira brevistriata</i>	3		7.75	1.70	
<i>Rhoicosphenia curvata</i>	3		0.97	5.09	
<i>Staurosira construens</i>	3		14.29	18.42	0.99
Number of Species Counted		34	70	76	53
Shannon Species Diversity		2.97	4.95	5.11	4.29
Pollution Index		1.85	2.46	2.42	1.93
Siltation Index		<u>93.78</u>	24.70	34.55	<u>87.32</u>
Disturbance Index		0.00	1.33	0.85	0.49
Percent Dominant Species		<u>46.52</u>	14.29	18.42	22.41
Percent Abnormal Cells		0.00	0.00	<u>0.48</u>	0.00
Similarity Index ³				49.91	13.67

¹A major diatom species accounts for 5.0% or more of the cells at one or more stations in a sample set.

²Pollution Tolerance Class (Lange-Bertalot 1979): 1 = most tolerant; 2 = tolerant; 3 = sensitive to organic pollution

³Percent Community Similarity (Whittaker 1952) when compared to the diatom assemblage at the adjacent upstream station

Table 5. Modal categories for selected ecological attributes of diatom species in Dog Creek and Eagle Creek.

Ecological Attribute	Dog Creek	Eagle Creek 01	Eagle Creek 02	Eagle Creek 03
Motility ¹	Highly Motile	Not Motile	Not Motile	Moderately Motile
pH ²	Alkaliphilous	Alkaliphilous	Alkaliphilous	Alkaliphilous
Salinity ²	Brackish-fresh	Fresh-brackish	Fresh-brackish	Brackish-fresh
Nitrogen Uptake ²	Facultative Nitrogen Heterotroph	Nitrogen Autotroph (high organics)	Nitrogen Autotroph (high organics)	Not Classified
Oxygen Demand ²	Moderate	Moderate	Continuously High	Not Classified
Saprobity ²	alpha-Mesosaprobous	beta-Mesosaprobous	beta-mesosaprobous	Not Classified
Trophic State ²	Eutraphentic	Eutraphentic	Eutraphentic	Eutraphentic
Moisture ²	Mainly in Waterbodies Regularly Wet	Mainly in Waterbodies Sometimes Wet	Rarely Outside Waterbodies	Mainly in Waterbodies Regularly Wet

¹Dr. R. Jan Stevenson, Michigan State University, digital communication.

²Van Dam et al. 1994



Appendix A: Aquatic Plant Field Sheets

AQUATIC PLANT FIELD SHEET

Date: 8/21/2002 Site Visit Code:
Waterbody Dog Creek STORET Station ID: M23DOGC01
Personnel: Ridenour

Purpose: The purpose of completing this form is to estimate the percent of wetted substrates at the sampling site covered by each of the major categories of aquatic plants, to record the relative amount of accumulated growth in each category, and to note the general color and condition of plants in each category. This information will help to describe the health and productivity of the aquatic ecosystem, define nuisance aquatic plant problems, identify potential sources and causes of pollution, and document changes in the plant community over time.

Type of plant growth	Cover (%)	Amount of growth	Color	Condition
Microalgae				
Macroalgae	10			
Mosses				
Macrophytes				
Bare substrate	~90			
Total	100 %			

Substrates present (please rank):

rock: 1
wood:
sediment: 2
other (list): 3
1) Grass
2) Macrophytes ?
3)
4)
5)

Explanation and Definitions

Cover: Estimate the percent of wetted substrate area colonized by each of the plant categories listed, and the percent area that is not colonized by any plants (see **Bare Substrate**, overleaf). Also, rank the types of substrates that are available for colonization by plants (1 = substrate accounting for the most area, etc.).

Amount: Record the relative amount of plant growth in each category as being **light**, **moderate**, or **heavy**. **Light** growth barely covers the substrate surface and is not immediately evident. **Heavy** growth extends almost to the water surface or beyond. **Moderate** growth is intermediate between light growth and heavy growth.

Color: The colors of aquatic plants are clues to their identity and to the health of aquatic ecosystems. Plant colors may span the spectrum of hues in the rainbow (see **Microalgae** below). Record the predominant color of the plants in each of the categories present.

Condition: Aquatic plants go through seasonal cycles of growth, maturity, and decay. The condition of a plant or group of plants will indicate the stage of this seasonal cycle. **Growing** plants show new growth and bright colors. **Mature** plants are larger but have more subdued colors because of age, epiphytes and sediment deposits. **Decaying** plants display a loss of both pigmentation and physical integrity. Enter **growing**, **mature**, or **decaying**.

Microalgae: Microalgae are microscopic algae appearing as pigmented accumulations attached to or resting upon submerged surfaces. This category commonly includes diatom "slimes" and films of green, blue-green, or euglenoid algae in depositional areas. Colors may range through shades of yellow, red, brown, green, blue and black. Included here are accumulations of "sewage fungus" (tan-gray) below sources of organic pollution, "yellow boy" (yellow-orange) below mine adits, and iron bacteria (orange-brown) in groundwater seeps and springs.

Macroalgae: Macroalgae are macroscopic algae whose individual plants or colonies are visible to the unaided eye. Macroalgae may be free-floating, or they may be attached to or resting upon submerged surfaces. Examples of macroalgae include filamentous growth forms (*Cladophora*, *Spirogyra*, *Ulothrix*), plant-like algae with leaf-like structures (*Chara*, *Nitella*), compact round or flattened colonies (*Nostoc*, *Rivularia*), gelatinous masses (*Chaetophora*, *Tetraspora*), and short, tubular strands (*Lemanea*). Color is highly variable, as it is with the microalgae.

Moss: Mosses are primitive plants that are intermediate in complexity between algae and higher plants. Mosses are common in cold-water habitats in western Montana. Mosses are typically green in color; the shade of green varies with plant vigor and the amount of sediment accumulation.

Macrophytes: Macrophytes or "higher plants" are distinguished from algae and mosses by their larger size and by the presence of true leaves, roots and flowers. Rooted macrophytes typically colonize areas of sediment deposition. Macrophytes may be free-floating (duckweed), submergent (pondweed), or emergent (cattails, bulrush, water lily).

Bare Substrate: Substrates may be void of plant growth because of toxic or sterile conditions or because of recently scoured or unstable substrates. Rocks in mountain lakes and streams may appear to be barren at first glance, but closer examination often reveals a very thin film of diatoms (microalgae) that feels slippery or slimy to the touch. Similarly, nearshore sediment deposits that have not been disturbed for several days will usually develop a film of microalgae. Examine these substrates closely.

AQUATIC PLANT FIELD SHEET

Date: 8/22/2002

Site Visit Code: 02-L411-

Waterbody Eagle Creek

STORET Station

ID: M23EAGLC01

Personnel: Ridenour

Purpose: The purpose of completing this form is to estimate the percent of wetted substrates at the sampling site covered by each of the major categories of aquatic plants, to record the relative amount of accumulated growth in each category, and to note the general color and condition of plants in each category. This information will help to describe the health and productivity of the aquatic ecosystem, define nuisance aquatic plant problems, identify potential sources and causes of pollution, and document changes in the plant community over time.

Type of plant growth	Cover (%)	Amount of growth	Color	Condition
Microalgae				
Macroalgae	10		Bright Green	Growing
Mosses	1		Dark Green	Mature
Macrophytes	20		Green	Growing to Mature
Bare substrate	69			
Total	100 %			

Substrates present (please rank):

rock: 1

wood: 2

sediment: 3

other (list): 4

1) Filamentous Algae

2) Macrophytes

3)

4)

5)

Explanation and Definitions

Cover: Estimate the percent of wetted substrate area colonized by each of the plant categories listed, and the percent area that is not colonized by any plants (see **Bare Substrate**, overleaf). Also, rank the types of substrates that are available for colonization by plants (1 = substrate accounting for the most area, etc.).

Amount: Record the relative amount of plant growth in each category as being **light**, **moderate**, or **heavy**. **Light** growth barely covers the substrate surface and is not immediately evident. **Heavy** growth extends almost to the water surface or beyond. **Moderate** growth is intermediate between light growth and heavy growth.

Color: The colors of aquatic plants are clues to their identity and to the health of aquatic ecosystems. Plant colors may span the spectrum of hues in the rainbow (see **Microalgae** below). Record the predominant color of the plants in each of the categories present.

Condition: Aquatic plants go through seasonal cycles of growth, maturity, and decay. The condition of a plant or group of plants will indicate the stage of this seasonal cycle. **Growing** plants show new growth and bright colors. **Mature** plants are larger but have more subdued colors because of age, epiphytes and sediment deposits. **Decaying** plants display a loss of both pigmentation and physical integrity. Enter **growing**, **mature**, or **decaying**.

Microalgae: Microalgae are microscopic algae appearing as pigmented accumulations attached to or resting upon submerged surfaces. This category commonly includes diatom "slimes" and films of green, blue-green, or euglenoid algae in depositional areas. Colors may range through shades of yellow, red, brown, green, blue and black. Included here are accumulations of "sewage fungus" (tan-gray) below sources of organic pollution, "yellow boy" (yellow-orange) below mine adits, and iron bacteria (orange-brown) in groundwater seeps and springs.

Macroalgae: Macroalgae are macroscopic algae whose individual plants or colonies are visible to the unaided eye. Macroalgae may be free-floating, or they may be attached to or resting upon submerged surfaces. Examples of macroalgae include filamentous growth forms (*Cladophora*, *Spirogyra*, *Ulothrix*), plant-like algae with leaf-like structures (*Chara*, *Nitella*), compact round or flattened colonies (*Nostoc*, *Rivularia*), gelatinous masses (*Chaetophora*, *Tetraspora*), and short, tubular strands (*Lemanea*). Color is highly variable, as it is with the microalgae.

Moss: Mosses are primitive plants that are intermediate in complexity between algae and higher plants. Mosses are common in cold-water habitats in western Montana. Mosses are typically green in color; the shade of green varies with plant vigor and the amount of sediment accumulation.

Macrophytes: Macrophytes or "higher plants" are distinguished from algae and mosses by their larger size and by the presence of true leaves, roots and flowers. Rooted macrophytes typically colonize areas of sediment deposition. Macrophytes may be free-floating (duckweed), submergent (pondweed), or emergent (cattails, bulrush, water lily).

Bare Substrate: Substrates may be void of plant growth because of toxic or sterile conditions or because of recently scoured or unstable substrates. Rocks in mountain lakes and streams may appear to be barren at first glance, but closer examination often reveals a very thin film of diatoms (microalgae) that feels slippery or slimy to the touch. Similarly, nearshore sediment deposits that have not been disturbed for several days will usually develop a film of microalgae. Examine these substrates closely.

AQUATIC PLANT FIELD SHEET

Date: 8/22/2002

Site Visit Code: 02-L408-

Waterbody Eagle Creek

STORET Station

ID: M23EAGLC02

Personnel: Ridenour

Purpose: The purpose of completing this form is to estimate the percent of wetted substrates at the sampling site covered by each of the major categories of aquatic plants, to record the relative amount of accumulated growth in each category, and to note the general color and condition of plants in each category. This information will help to describe the health and productivity of the aquatic ecosystem, define nuisance aquatic plant problems, identify potential sources and causes of pollution, and document changes in the plant community over time.

Type of plant growth	Cover (%)	Amount of growth	Color	Condition
Microalgae	40		bright green	growing to mature
Macroalgae				
Mosses				
Macrophytes	40		green, some flowers	maturing
Bare substrate	20			
Total	100 %			

Substrates present (please rank):

rock: 1

wood: 4

sediment: 2

other (list): 3

1) Macrophytes

2) Filamentous algae

3)

4)

5)

Explanation and Definitions

Cover: Estimate the percent of wetted substrate area colonized by each of the plant categories listed, and the percent area that is not colonized by any plants (see **Bare Substrate**, overleaf). Also, rank the types of substrates that are available for colonization by plants (1 = substrate accounting for the most area, etc.).

Amount: Record the relative amount of plant growth in each category as being **light**, **moderate**, or **heavy**. **Light** growth barely covers the substrate surface and is not immediately evident. **Heavy** growth extends almost to the water surface or beyond. **Moderate** growth is intermediate between light growth and heavy growth.

Color: The colors of aquatic plants are clues to their identity and to the health of aquatic ecosystems. Plant colors may span the spectrum of hues in the rainbow (see **Microalgae** below). Record the predominant color of the plants in each of the categories present.

Condition: Aquatic plants go through seasonal cycles of growth, maturity, and decay. The condition of a plant or group of plants will indicate the stage of this seasonal cycle. **Growing** plants show new growth and bright colors. **Mature** plants are larger but have more subdued colors because of age, epiphytes and sediment deposits. **Decaying** plants display a loss of both pigmentation and physical integrity. Enter **growing**, **mature**, or **decaying**.

Microalgae: Microalgae are microscopic algae appearing as pigmented accumulations attached to or resting upon submerged surfaces. This category commonly includes diatom "slimes" and films of green, blue-green, or euglenoid algae in depositional areas. Colors may range through shades of yellow, red, brown, green, blue and black. Included here are accumulations of "sewage fungus" (tan-gray) below sources of organic pollution, "yellow boy" (yellow-orange) below mine adits, and iron bacteria (orange-brown) in groundwater seeps and springs.

Macroalgae: Macroalgae are macroscopic algae whose individual plants or colonies are visible to the unaided eye. Macroalgae may be free-floating, or they may be attached to or resting upon submerged surfaces. Examples of macroalgae include filamentous growth forms (*Cladophora*, *Spirogyra*, *Ulothrix*), plant-like algae with leaf-like structures (*Chara*, *Nitella*), compact round or flattened colonies (*Nostoc*, *Rivularia*), gelatinous masses (*Chaetophora*, *Tetraspora*), and short, tubular strands (*Lemanea*). Color is highly variable, as it is with the microalgae.

Moss: Mosses are primitive plants that are intermediate in complexity between algae and higher plants. Mosses are common in cold-water habitats in western Montana. Mosses are typically green in color; the shade of green varies with plant vigor and the amount of sediment accumulation.

Macrophytes: Macrophytes or "higher plants" are distinguished from algae and mosses by their larger size and by the presence of true leaves, roots and flowers. Rooted macrophytes typically colonize areas of sediment deposition. Macrophytes may be free-floating (duckweed), submergent (pondweed), or emergent (cattails, bulrush, water lily).

Bare Substrate: Substrates may be void of plant growth because of toxic or sterile conditions or because of recently scoured or unstable substrates. Rocks in mountain lakes and streams may appear to be barren at first glance, but closer examination often reveals a very thin film of diatoms (microalgae) that feels slippery or slimy to the touch. Similarly, nearshore sediment deposits that have not been disturbed for several days will usually develop a film of microalgae. Examine these substrates closely.

AQUATIC PLANT FIELD SHEET

Date: 8/22/2002 Site Visit Code: 02-L410-
Waterbody Eagle Creek STORET Station ID: M23EAGLC03
Personnel: Ridenour

Purpose: The purpose of completing this form is to estimate the percent of wetted substrates at the sampling site covered by each of the major categories of aquatic plants, to record the relative amount of accumulated growth in each category, and to note the general color and condition of plants in each category. This information will help to describe the health and productivity of the aquatic ecosystem, define nuisance aquatic plant problems, identify potential sources and causes of pollution, and document changes in the plant community over time.

Type of plant growth	Cover (%)	Amount of growth	Color	Condition
Microalgae				
Macroalgae	20		green-brown	mature to dying?
Mosses	1		dark green	mature
Macrophytes	20		dark green	maturing
Bare substrate	59			
Total	100 %			

Substrates present (please rank):

rock: 1
wood:
sediment: 2
other (list): 3
1) filamentous algae
2)
3)
4)
5)

Explanation and Definitions

Cover: Estimate the percent of wetted substrate area colonized by each of the plant categories listed, and the percent area that is not colonized by any plants (see **Bare Substrate**, overleaf). Also, rank the types of substrates that are available for colonization by plants (1 = substrate accounting for the most area, etc.).

Amount: Record the relative amount of plant growth in each category as being **light**, **moderate**, or **heavy**. **Light** growth barely covers the substrate surface and is not immediately evident. **Heavy** growth extends almost to the water surface or beyond. **Moderate** growth is intermediate between light growth and heavy growth.

Color: The colors of aquatic plants are clues to their identity and to the health of aquatic ecosystems. Plant colors may span the spectrum of hues in the rainbow (see **Microalgae** below). Record the predominant color of the plants in each of the categories present.

Condition: Aquatic plants go through seasonal cycles of growth, maturity, and decay. The condition of a plant or group of plants will indicate the stage of this seasonal cycle. **Growing** plants show new growth and bright colors. **Mature** plants are larger but have more subdued colors because of age, epiphytes and sediment deposits. **Decaying** plants display a loss of both pigmentation and physical integrity. Enter **growing**, **mature**, or **decaying**.

Microalgae: Microalgae are microscopic algae appearing as pigmented accumulations attached to or resting upon submerged surfaces. This category commonly includes diatom "slimes" and films of green, blue-green, or euglenoid algae in depositional areas. Colors may range through shades of yellow, red, brown, green, blue and black. Included here are accumulations of "sewage fungus" (tan-gray) below sources of organic pollution, "yellow boy" (yellow-orange) below mine adits, and iron bacteria (orange-brown) in groundwater seeps and springs.

Macroalgae: Macroalgae are macroscopic algae whose individual plants or colonies are visible to the unaided eye. Macroalgae may be free-floating, or they may be attached to or resting upon submerged surfaces. Examples of macroalgae include filamentous growth forms (*Cladophora*, *Spirogyra*, *Ulothrix*), plant-like algae with leaf-like structures (*Chara*, *Nitella*), compact round or flattened colonies (*Nostoc*, *Rivularia*), gelatinous masses (*Chaetophora*, *Tetraspora*), and short, tubular strands (*Lemanea*). Color is highly variable, as it is with the microalgae.

Moss: Mosses are primitive plants that are intermediate in complexity between algae and higher plants. Mosses are common in cold-water habitats in western Montana. Mosses are typically green in color; the shade of green varies with plant vigor and the amount of sediment accumulation.

Macrophytes: Macrophytes or "higher plants" are distinguished from algae and mosses by their larger size and by the presence of true leaves, roots and flowers. Rooted macrophytes typically colonize areas of sediment deposition. Macrophytes may be free-floating (duckweed), submergent (pondweed), or emergent (cattails, bulrush, water lily).

Bare Substrate: Substrates may be void of plant growth because of toxic or sterile conditions or because of recently scoured or unstable substrates. Rocks in mountain lakes and streams may appear to be barren at first glance, but closer examination often reveals a very thin film of diatoms (microalgae) that feels slippery or slimy to the touch. Similarly, nearshore sediment deposits that have not been disturbed for several days will usually develop a film of microalgae. Examine these substrates closely.

Appendix B: Diatom Reports

Hannaea

1032 12th Avenue Helena, MT 59601 (406) 443-2196

hannaea@montana.com

Diatom Report

Sample: 259101

Client ID: M23EAGLC03

Sample Location: Eagle Creek near mouth

Sample Date: 8/22/02

Diatom Species

Genus/Species/Variety	Percent Relative Abundance
<i>Achnanthyidium minutissimum</i>	0.49
<i>Amphipleura pellucida</i>	0.25
<i>Caloneis bacillum</i>	0.25
<i>Cyclotella meneghiniana</i>	0.37
<i>Cylindrotheca gracilis</i>	0.25
<i>Diploneis boldtiana</i>	0.62
<i>Diploneis elliptica</i>	0.25
<i>Diploneis puella</i>	3.94
<i>Entomoneis paludosa</i>	0.25
<i>Epithemia adnata</i>	0.74
<i>Epithemia sorex</i>	1.11
<i>Epithemia turgida</i>	0.25
<i>Fragilaria exigua</i>	0.99
<i>Gomphonema parvulum</i>	0.25
<i>Navicula agrestis</i>	0.25
<i>Navicula amphiceropsis</i>	0.25
<i>Navicula cryptotenelloides</i>	2.59
<i>Navicula duerrenbergiana</i>	1.11
<i>Navicula erifuga</i>	2.83
<i>Navicula gregaria</i>	0.49
<i>Navicula perminuta</i>	0.86
<i>Navicula recens</i>	3.08
<i>Navicula salinicola</i>	3.08
<i>Navicula symmetrica</i>	22.41
<i>Navicula vandamii</i>	6.28
<i>Navicula veneta</i>	2.71
<i>Navicula vilaplanii</i>	9.61
<i>Nitzschia agnita</i>	0.25
<i>Nitzschia alpina</i>	0.25

Hannaea

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Diatom Report

<i>Nitzschia archibaldii</i>	1.35
<i>Nitzschia capitellata</i>	0.25
<i>Nitzschia dissipata</i>	3.2
<i>Nitzschia filiformis</i>	0.62
<i>Nitzschia graciliformis</i>	0.99
<i>Nitzschia inconspicua</i>	6.53
<i>Nitzschia liebetruhii</i>	1.48
<i>Nitzschia lorenziana</i>	0.37
<i>Nitzschia microcephala</i>	0.74
<i>Nitzschia palea</i>	1.23
<i>Nitzschia perminuta</i>	0.25
<i>Nitzschia reversa</i>	12.81
<i>Nitzschia sigma</i>	0.12
<i>Nitzschia sigmoidea</i>	0.37
<i>Nitzschia siliqua</i>	0.25
<i>Pleurosigma delicatulum</i>	0.74
<i>Rhopalodia gibba</i>	0.49
<i>Rhopalodia operculata</i>	0.25
<i>Simonsenia delognei</i>	0.12
<i>Staurosira construens</i>	0.99
<i>Surirella brebissonii</i>	0.12
<i>Synedra parasitica</i>	0.25
<i>Tryblionella apiculata</i>	0.25
<i>Tryblionella debilis</i>	0.25

Diatom Metrics

Metric	Category	Value
Valves Counted	--	812
Cells Counted	--	406
Total Number of Species	--	53
Total Number of Species Counted	--	53
Percent Dominant Species	--	22.41
Shannon's Diversity Index	--	4.29
Pollution Index	--	1.93
Pollution Tolerance (% by Category)	Most Tolerant	16.13
Pollution Tolerance (% by Category)	Tolerant	75.12
Pollution Tolerance (% by Category)	Sensitive	8.74

Hannaea

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Diatom Report

Siltation Index	--	87.32
Disturbance Index	--	0.49
Stability Index	--	2.22
Percent Epithemiaceae	--	2.83
Percent Aerophiles	--	6.4
Percent Centrics	--	0.37
Motility (% by Category)	Highly Motile	33
Motility (% by Category)	Moderately Motile	54.06
Motility (% by Category)	Not Motile	3.33
Motility (% by Category)	Variable Motility	0
pH (% by Category)	Not Classified	34.61
pH (% by Category)	Acidobiontic	0
pH (% by Category)	Acidophilous	0
pH (% by Category)	Circumneutral	4.8
pH (% by Category)	Alkaliphilous	58
pH (% by Category)	Alkalibiontic	2.59
pH (% by Category)	Indifferent	0
Salinity (% by Category)	Not Classified	16.75
Salinity (% by Category)	Fresh	1.23
Salinity (% by Category)	Fresh-brackish	24.14
Salinity (% by Category)	Brackish-fresh	39.16
Salinity (% by Category)	Brackish	18.72
Salinity (% by Category)	Marine	0
Nitrogen Uptake (% by Category)	Not Classified	71.06
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (low organics)	9.73
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (high organics)	9.48
Nitrogen Uptake (% by Category)	Facultative Nitrogen Heterotroph	7.76
Nitrogen Uptake (% by Category)	Obligate Nitrogen Heterotroph	1.97
Oxygen Demand (% by Category)	Not Classified	48.28
Oxygen Demand (% by Category)	Continuously High	30.42
Oxygen Demand (% by Category)	Fairly High	7.14
Oxygen Demand (% by Category)	Moderate	9.11
Oxygen Demand (% by Category)	Low	4.68
Oxygen Demand (% by Category)	Very Low	0.37
Saprobity (% by Category)	Not Classified	43.72
Saprobity (% by Category)	Oligosaprobous	5.91
Saprobity (% by Category)	beta-Mesosaprobous	33.13
Saprobity (% by Category)	alpha-Mesosaprobous	12.19

Hannaea

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Diatom Report

Saprobity (% by Category)	alpha-Mesosaprobous/Polysaprobous	3.82
Saprobity (% by Category)	Polysaprobous	1.23
Trophic State (% by Category)	Not Classified	34.85
Trophic State (% by Category)	Oligotraphentic	1.23
Trophic State (% by Category)	Oligo-mesotraphentic	0.49
Trophic State (% by Category)	Mesotraphentic	4.19
Trophic State (% by Category)	Meso-eutraphentic	5.67
Trophic State (% by Category)	Eutraphentic	51.6
Trophic State (% by Category)	Hypereutraphentic	1.48
Trophic State (% by Category)	Variable	0.49
Trophic State (% by Category)	Dystrophic	0
Moisture (% by Category)	Not Classified	43.23
Moisture (% by Category)	Rarely Outside Waterbodies	1.97
Moisture (% by Category)	Mainly in Waterbodies; Sometimes Wet	7.51
Moisture (% by Category)	Mainly in Waterbodies; Regularly Wet	46.8
Moisture (% by Category)	Mainly Wet Places; Sometimes in Water	0.49
Moisture (% by Category)	Exclusively Outside Waterbodies	0
Similarity Index	Reference Sample ID: 258901	10.77

Hannaea

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Diatom Report

Sample: 259001

Client ID: M23EAGLC02

Sample Location: Eagle Creek below Highway 236

Sample Date: 8/22/02

Diatom Species

Genus/Species/Variety	Percent Relative Abundance
<i>Achnanthes lanceolata</i>	2.67
<i>Achnanthidium minutissimum</i>	0.85
<i>Amphipleura pellucida</i>	0.73
<i>Amphora libyca</i>	0.61
<i>Amphora pediculus</i>	1.45
<i>Caloneis bacillum</i>	0.85
<i>Cocconeis pediculus</i>	0.36
<i>Cocconeis placentula</i>	2.91
<i>Cyclotella meneghiniana</i>	1.94
<i>Cymbella mexicana</i>	0.12
<i>Diatoma vulgare</i>	0.73
<i>Encyonema cespitosum</i>	4.36
<i>Epithemia sorex</i>	0.73
<i>Fallacia monoculata</i>	0.24
<i>Fragilaria exigua</i>	3.76
<i>Fragilaria nanana</i>	0.61
<i>Fragilaria pseudoconstruens</i>	3.15
<i>Fragilaria vaucheriae</i>	4.61
<i>Gomphonema acuminatum</i>	0.24
<i>Gomphonema minutum</i>	0.73
<i>Gomphonema olivaceum</i>	1.09
<i>Gomphonema parvulum</i>	0.73
<i>Gyrosigma acuminatum</i>	0.24
<i>Navicula capitata</i>	0.36
<i>Navicula capitatoradiata</i>	7.15
<i>Navicula circumtexta</i>	0.12
<i>Navicula erifuga</i>	0.48
<i>Navicula gregaria</i>	2.67
<i>Navicula integra</i>	0.24

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Diatom Report

<i>Navicula lanceolata</i>	0.48
<i>Navicula libonensis</i>	0.36
<i>Navicula minima</i>	0.48
<i>Navicula perminuta</i>	0.24
<i>Navicula protracta</i>	0.24
<i>Navicula reichardtiana</i>	2.79
<i>Navicula soehrensii</i>	0.24
<i>Navicula streckeri</i>	0.73
<i>Navicula tripunctata</i>	0.24
<i>Navicula trivialis</i>	0.24
<i>Navicula veneta</i>	1.21
<i>Navicula vilaplana</i>	0.24
<i>Nitzschia acicularis</i>	0.24
<i>Nitzschia archibaldii</i>	0.48
<i>Nitzschia capitellata</i>	0.24
<i>Nitzschia communis</i>	0.24
<i>Nitzschia dissipata</i>	1.33
<i>Nitzschia draveillensis</i>	0.48
<i>Nitzschia hantzschiana</i>	0.24
<i>Nitzschia inconspicua</i>	1.58
<i>Nitzschia linearis</i>	0.12
<i>Nitzschia microcephala</i>	0.24
<i>Nitzschia palea</i>	1.94
<i>Nitzschia paleacea</i>	3.39
<i>Nitzschia reversa</i>	0.12
<i>Nitzschia sociabilis</i>	0.12
<i>Nitzschia solita</i>	0.48
<i>Nitzschia supralitorea</i>	1.7
<i>Placoneis elginensis</i>	0.24
<i>Pleurosigma delicatulum</i>	0.48
<i>Pseudostaurosira brevistriata</i>	1.7
<i>Rhoicosphenia curvata</i>	5.09
<i>Rhopalodia gibba</i>	0.24
<i>Rhopalodia operculata</i>	0.24
<i>Sellaphora pupula</i>	0.48
<i>Simonsenia delognei</i>	0.36
<i>Staurosira construens</i>	18.42
<i>Staurosirella leptostauron</i>	0.36

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Diatom Report

<i>Staurosirella pinnata</i>	2.42
<i>Surirella brebissonii</i>	0.48
<i>Surirella minuta</i>	0.73
<i>Synedra acus</i>	0.24
<i>Synedra parasitica</i>	1.45
<i>Synedra ulna</i>	1.09
<i>Thalassiosira weissflogii</i>	0.24
<i>Tryblionella calida</i>	0.24
<i>Tryblionella hungarica</i>	0.24

Diatom Metrics

Metric	Category	Value
Valves Counted	--	825
Cells Counted	--	412.5
Total Number of Species	--	76
Total Number of Species Counted	--	76
Percent Dominant Species	--	18.42
Shannon's Diversity Index	--	5.11
Pollution Index	--	2.42
Pollution Tolerance (% by Category)	Most Tolerant	5.94
Pollution Tolerance (% by Category)	Tolerant	46.18
Pollution Tolerance (% by Category)	Sensitive	47.88
Siltation Index	--	34.55
Disturbance Index	--	0.85
Stability Index	--	38.55
Percent Epithemiaceae	--	1.21
Percent Aerophiles	--	14.18
Percent Centrics	--	2.18
Motility (% by Category)	Highly Motile	15.76
Motility (% by Category)	Moderately Motile	23.39
Motility (% by Category)	Not Motile	55.39
Motility (% by Category)	Variable Motility	4.48
pH (% by Category)	Not Classified	11.76
pH (% by Category)	Acidobiontic	0
pH (% by Category)	Acidophilous	0.24
pH (% by Category)	Circumneutral	12.12
pH (% by Category)	Alkaliphilous	72.85

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Diatom Report

pH (% by Category)	Alkalibiontic	3.03
pH (% by Category)	Indifferent	0
Salinity (% by Category)	Not Classified	4.85
Salinity (% by Category)	Fresh	4.85
Salinity (% by Category)	Fresh-brackish	77.33
Salinity (% by Category)	Brackish-fresh	12.12
Salinity (% by Category)	Brackish	0.85
Salinity (% by Category)	Marine	0
Nitrogen Uptake (% by Category)	Not Classified	17.21
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (low organics)	28.85
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (high organics)	40.97
Nitrogen Uptake (% by Category)	Facultative Nitrogen Heterotroph	6.91
Nitrogen Uptake (% by Category)	Obligate Nitrogen Heterotroph	6.06
Oxygen Demand (% by Category)	Not Classified	16.12
Oxygen Demand (% by Category)	Continuously High	30.42
Oxygen Demand (% by Category)	Fairly High	16.61
Oxygen Demand (% by Category)	Moderate	27.39
Oxygen Demand (% by Category)	Low	7.52
Oxygen Demand (% by Category)	Very Low	1.94
Saprobity (% by Category)	Not Classified	8
Saprobity (% by Category)	Oligosaprobous	6.91
Saprobity (% by Category)	beta-Mesosaprobous	41.21
Saprobity (% by Category)	alpha-Mesosaprobous	35.27
Saprobity (% by Category)	alpha-Mesosaprobous/Polysaprobous	6.67
Saprobity (% by Category)	Polysaprobous	1.94
Trophic State (% by Category)	Not Classified	9.09
Trophic State (% by Category)	Oligotraphentic	4
Trophic State (% by Category)	Oligo-mesotraphentic	1.33
Trophic State (% by Category)	Mesotraphentic	0.24
Trophic State (% by Category)	Meso-eutraphentic	24.12
Trophic State (% by Category)	Eutraphentic	48.36
Trophic State (% by Category)	Hypereutraphentic	2.42
Trophic State (% by Category)	Variable	10.42
Trophic State (% by Category)	Dystrophic	0
Moisture (% by Category)	Not Classified	15.88
Moisture (% by Category)	Rarely Outside Waterbodies	29.45
Moisture (% by Category)	Mainly in Waterbodies; Sometimes Wet	26.55
Moisture (% by Category)	Mainly in Waterbodies; Regularly Wet	25.7

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Moisture (% by Category)	Mainly Wet Places; Sometimes in Water	2.42
Moisture (% by Category)	Exclusively Outside Waterbodies	0
Similarity Index	Reference Sample ID: 259101	13.67

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Diatom Report

Sample: 258901

Client ID: M23EAGLC01

Sample Location: Eagle Creek upper site on IX Ranch

Sample Date: 8/22/02

Diatom Species

Genus/Species/Variety	Percent Relative Abundance
<i>Achnanthes lanceolata</i>	3.39
<i>Achnanthidium minutissimum</i>	1.33
<i>Amphora inariensis</i>	0.48
<i>Amphora libyca</i>	0.73
<i>Caloneis bacillum</i>	0.24
<i>Caloneis schumanniana</i>	0.73
<i>Cocconeis pediculus</i>	0.61
<i>Cocconeis placentula</i>	6.42
<i>Cyclotella bodanica</i>	1.09
<i>Cyclotella meneghiniana</i>	2.06
<i>Diatoma vulgare</i>	0.48
<i>Diploneis elliptica</i>	0.12
<i>Epithemia adnata</i>	0.73
<i>Epithemia sorex</i>	4.24
<i>Epithemia turgida</i>	0.24
<i>Eunotia bilunaris</i>	0.12
<i>Fragilaria capucina</i>	4
<i>Fragilaria crotonensis</i>	0.36
<i>Fragilaria nanana</i>	0.24
<i>Fragilaria vaucheriae</i>	12.71
<i>Frustulia vulgare</i>	0.12
<i>Gomphonema acuminatum</i>	0.24
<i>Gomphonema innocens</i>	1.45
<i>Gomphonema olivaceum</i>	1.21
<i>Gomphonema parvulum</i>	1.21
<i>Gomphonema pumilum</i>	0.48
<i>Gomphonema truncatum</i>	0.24
<i>Melosira varians</i>	1.94
<i>Meridion circulare</i>	2.18

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<i>Navicula antonii</i>	0.24
<i>Navicula capitata</i>	0.24
<i>Navicula capitatoradiata</i>	0.61
<i>Navicula cryptotenella</i>	0.12
<i>Navicula gregaria</i>	1.94
<i>Navicula hustedtii</i>	0.73
<i>Navicula lanceolata</i>	0.12
<i>Navicula libonensis</i>	0.97
<i>Navicula minima</i>	0.24
<i>Navicula reichardtiana</i>	4.24
<i>Navicula trivialis</i>	0.24
<i>Navicula veneta</i>	0.73
<i>Nitzschia agnita</i>	0.73
<i>Nitzschia archibaldii</i>	2.42
<i>Nitzschia dissipata</i>	0.97
<i>Nitzschia draveillensis</i>	0.48
<i>Nitzschia flexa</i>	0.24
<i>Nitzschia fonticola</i>	0.85
<i>Nitzschia hantzschiana</i>	1.21
<i>Nitzschia linearis</i>	0.97
<i>Nitzschia palea</i>	1.45
<i>Nitzschia paleacea</i>	0.61
<i>Nitzschia perminuta</i>	0.24
<i>Nitzschia recta</i>	0.36
<i>Nitzschia sigmoidea</i>	0.12
<i>Placoneis placentula</i>	0.24
<i>Pseudostaurosira brevistriata</i>	7.75
<i>Reimeria sinuata</i>	0.61
<i>Rhoicosphenia curvata</i>	0.97
<i>Rhopalodia gibba</i>	0.36
<i>Rhopalodia operculata</i>	0.24
<i>Sellaphora mutata</i>	0.24
<i>Sellaphora pupula</i>	0.48
<i>Staurosira construens</i>	14.29
<i>Staurosirella pinnata</i>	0.48
<i>Surirella angusta</i>	0.24
<i>Surirella minuta</i>	1.09
<i>Synedra ulna</i>	1.21

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<i>Tryblionella apiculata</i>	0.97
<i>Tryblionella calida</i>	0.12
<i>Tryblionella hungarica</i>	0.24

Diatom Metrics

Metric	Category	Value
Valves Counted	--	826
Cells Counted	--	413
Total Number of Species	--	70
Total Number of Species Counted	--	70
Percent Dominant Species	--	14.29
Shannon's Diversity Index	--	4.95
Pollution Index	--	2.46
Pollution Tolerance (% by Category)	Most Tolerant	4.84
Pollution Tolerance (% by Category)	Tolerant	44.79
Pollution Tolerance (% by Category)	Sensitive	50.36
Siltation Index	--	24.7
Disturbance Index	--	1.33
Stability Index	--	41.53
Percent Epithemiaceae	--	5.81
Percent Aerophiles	--	25.42
Percent Centrics	--	5.08
Motility (% by Category)	Highly Motile	13.32
Motility (% by Category)	Moderately Motile	20.22
Motility (% by Category)	Not Motile	66.34
Motility (% by Category)	Variable Motility	0.12
pH (% by Category)	Not Classified	4.96
pH (% by Category)	Acidobiontic	0
pH (% by Category)	Acidophilous	0.73
pH (% by Category)	Circumneutral	14.53
pH (% by Category)	Alkaliphilous	71.67
pH (% by Category)	Alkalibiontic	7.99
pH (% by Category)	Indifferent	0.12
Salinity (% by Category)	Not Classified	1.69
Salinity (% by Category)	Fresh	3.27
Salinity (% by Category)	Fresh-brackish	86.32
Salinity (% by Category)	Brackish-fresh	7.02

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Diatom Report

Salinity (% by Category)	Brackish	1.69
Salinity (% by Category)	Marine	0
Nitrogen Uptake (% by Category)	Not Classified	15.86
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (low organics)	31.96
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (high organics)	44.67
Nitrogen Uptake (% by Category)	Facultative Nitrogen Heterotroph	5.45
Nitrogen Uptake (% by Category)	Obligate Nitrogen Heterotroph	2.06
Oxygen Demand (% by Category)	Not Classified	14.77
Oxygen Demand (% by Category)	Continuously High	27.48
Oxygen Demand (% by Category)	Fairly High	19.37
Oxygen Demand (% by Category)	Moderate	30.51
Oxygen Demand (% by Category)	Low	5.81
Oxygen Demand (% by Category)	Very Low	2.06
Saprobity (% by Category)	Not Classified	5.69
Saprobity (% by Category)	Oligosaprobous	11.62
Saprobity (% by Category)	beta-Mesosaprobous	46.97
Saprobity (% by Category)	alpha-Mesosaprobous	28.81
Saprobity (% by Category)	alpha-Mesosaprobous/Polysaprobous	5.45
Saprobity (% by Category)	Polysaprobous	1.45
Trophic State (% by Category)	Not Classified	8.6
Trophic State (% by Category)	Oligotraphentic	1.57
Trophic State (% by Category)	Oligo-mesotraphentic	0.73
Trophic State (% by Category)	Mesotraphentic	7.02
Trophic State (% by Category)	Meso-eutraphentic	19.85
Trophic State (% by Category)	Eutraphentic	46.73
Trophic State (% by Category)	Hypereutraphentic	1.45
Trophic State (% by Category)	Variable	14.04
Trophic State (% by Category)	Dystrophic	0
Moisture (% by Category)	Not Classified	15.86
Moisture (% by Category)	Rarely Outside Waterbodies	23.24
Moisture (% by Category)	Mainly in Waterbodies; Sometimes Wet	29.54
Moisture (% by Category)	Mainly in Waterbodies; Regularly Wet	29.42
Moisture (% by Category)	Mainly Wet Places; Sometimes in Water	1.94
Moisture (% by Category)	Exclusively Outside Waterbodies	0
Similarity Index	Reference Sample ID: 259001	49.91

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Diatom Report

Sample: 258801

Client ID: M23DOGCR01

Sample Location: Dog Creek at Econom

Sample Date: 8/21/02

Diatom Species

Genus/Species/Variety	Percent Relative Abundance
<i>Cyclotella meneghiniana</i>	2.24
<i>Cymbella pusilla</i>	1
<i>Encyonema silesiacum</i>	0.37
<i>Gomphonema clavatum</i>	0.5
<i>Gomphonema gracile</i>	0.25
<i>Gomphonema innocens</i>	1.37
<i>Luticola mutica</i>	0.25
<i>Navicula cryptofallax</i>	1.49
<i>Navicula duerrenbergiana</i>	0.25
<i>Navicula erifuga</i>	2.24
<i>Navicula gregaria</i>	0.25
<i>Navicula lundii</i>	0.5
<i>Navicula recens</i>	4.35
<i>Navicula salinarum</i>	0.25
<i>Navicula tripunctata</i>	0.12
<i>Navicula veneta</i>	1.87
<i>Nitzschia agnita</i>	0.25
<i>Nitzschia amphibia</i>	0.62
<i>Nitzschia archibaldii</i>	2.99
<i>Nitzschia capitellata</i>	0.37
<i>Nitzschia filiformis</i>	0.12
<i>Nitzschia fonticola</i>	0.37
<i>Nitzschia inconspicua</i>	46.52
<i>Nitzschia liebetruithii</i>	15.67
<i>Nitzschia lorenziana</i>	0.12
<i>Nitzschia microcephala</i>	0.25
<i>Nitzschia palea</i>	5.35
<i>Nitzschia paleacea</i>	0.25
<i>Nitzschia perspicua</i>	7.59

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Diatom Report

<i>Nitzschia reversa</i>	1.12
<i>Surirella patella</i>	0.25
<i>Thalassiosira pseudonana</i>	0.5
<i>Tryblionella apiculata</i>	0.12
<i>Tryblionella hungarica</i>	0.25

Diatom Metrics

Metric	Category	Value
Valves Counted	--	804
Cells Counted	--	402
Total Number of Species	--	34
Total Number of Species Counted	--	34
Percent Dominant Species	--	46.52
Shannon's Diversity Index	--	2.97
Pollution Index	--	1.85
Pollution Tolerance (% by Category)	Most Tolerant	16.79
Pollution Tolerance (% by Category)	Tolerant	81.34
Pollution Tolerance (% by Category)	Sensitive	1.87
Siltation Index	--	93.78
Disturbance Index	--	0
Stability Index	--	0
Percent Epithemiaceae	--	0
Percent Aerophiles	--	9.95
Percent Centrics	--	2.74
Motility (% by Category)	Highly Motile	82.21
Motility (% by Category)	Moderately Motile	11.57
Motility (% by Category)	Not Motile	4.85
Motility (% by Category)	Variable Motility	1.37
pH (% by Category)	Not Classified	21.52
pH (% by Category)	Acidobiontic	0
pH (% by Category)	Acidophilous	0
pH (% by Category)	Circumneutral	17.54
pH (% by Category)	Alkaliphilous	60.95
pH (% by Category)	Alkalibiontic	0
pH (% by Category)	Indifferent	0
Salinity (% by Category)	Not Classified	20.02
Salinity (% by Category)	Fresh	0.5

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Diatom Report

Salinity (% by Category)	Fresh-brackish	18.66
Salinity (% by Category)	Brackish-fresh	58.46
Salinity (% by Category)	Brackish	2.36
Salinity (% by Category)	Marine	0
Nitrogen Uptake (% by Category)	Not Classified	28.48
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (low organics)	0.75
Nitrogen Uptake (% by Category)	Nitrogen Autotroph (high organics)	14.93
Nitrogen Uptake (% by Category)	Facultative Nitrogen Heterotroph	50
Nitrogen Uptake (% by Category)	Obligate Nitrogen Heterotroph	5.85
Oxygen Demand (% by Category)	Not Classified	28.48
Oxygen Demand (% by Category)	Continuously High	1
Oxygen Demand (% by Category)	Fairly High	11.82
Oxygen Demand (% by Category)	Moderate	48.76
Oxygen Demand (% by Category)	Low	7.71
Oxygen Demand (% by Category)	Very Low	2.24
Saprobity (% by Category)	Not Classified	23.76
Saprobity (% by Category)	Oligosaprobous	0.75
Saprobity (% by Category)	beta-Mesosaprobous	11.82
Saprobity (% by Category)	alpha-Mesosaprobous	53.86
Saprobity (% by Category)	alpha-Mesosaprobous/Polysaprobous	4.48
Saprobity (% by Category)	Polysaprobous	5.35
Trophic State (% by Category)	Not Classified	21.52
Trophic State (% by Category)	Oligotraphentic	0
Trophic State (% by Category)	Oligo-mesotraphentic	0
Trophic State (% by Category)	Mesotraphentic	0.25
Trophic State (% by Category)	Meso-eutraphentic	0.87
Trophic State (% by Category)	Eutraphentic	63.18
Trophic State (% by Category)	Hypereutraphentic	6.22
Trophic State (% by Category)	Variable	7.96
Trophic State (% by Category)	Dystrophic	0
Moisture (% by Category)	Not Classified	24.5
Moisture (% by Category)	Rarely Outside Waterbodies	1.99
Moisture (% by Category)	Mainly in Waterbodies; Sometimes Wet	5.35
Moisture (% by Category)	Mainly in Waterbodies; Regularly Wet	67.91
Moisture (% by Category)	Mainly Wet Places; Sometimes in Water	0.25
Moisture (% by Category)	Exclusively Outside Waterbodies	0